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Review Article

Effect of Different types of Baffles on Heat Transfer & Pressure Drop of Shell and Tube Heat Exchanger: A review

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Abstract

Diverse sorts of heat exchangers are broadly utilized as a part of many design applications, for example, petroleum refining, refrigeration, cooling, nourishment industry, and so forth. Among various sorts of heat exchangers, manufacturing of shell and-tube heat exchanger is easy and multi-reason application conceivable outcomes for vaporous and fluid media in an extensive temperature and pressure territory. This paper manages a survey of exploratory research work that plans to look at the impacts of various baffles sorts on pressure loss and heat transfer in heat exchanger. Baffle is one of the basic part considered in design of STHE. Confuses, having an essential piece of STHE, offer help to keep of support tubes in bundle and as shell side it also helps to maintain the speed of stream. Different sorts of baffles are utilized as a part of STHEs. For example segmental, flower, ring, trefoil hole, plate and doughnut sort and helical. Be that as it may, conventional HX with segmental baffle indicate low heat exchange proficiency and extensive pressure loss. From the present review it can be inferred that helical baffles fill in as an all the more encouraging innovation due to having less loss of pressure in shell, better heat exchange execution, less fouling and less liquid incited vibration.

Keywords: *Baffles, Shell and Tube HX, Pressure drop, heat transfer coefficient, fouling, Fold baffles, Baffle shape.*

1. Introduction

Heat exchanger is an imperative mechanical assembly in general fields, for example, petroleum refining, refrigeration, cooling, nourishment industry, and so forth. Among the distinctive sorts of heat exchangers, shell-and tube heat exchanger contain many points of interest, for example, solid structure, develop procedures and wide pertinence, which make it generally used in different industries.

The main considerations influencing the efficiency of STHE are turbulence, pressure drop, heat exchange coefficient, fouling, and proportion or amount of stream rates on tube to shell side, length of heat exchanger and baffle types. By expanding turbulence power level, resistance to stream also expanded, which upgrades the heat exchange adequately. Heat exchange rate can be improved with high pressure loss however it prompts to increase in power consumption, which is its real downside. Thus, estimation of streamlined pressure drop for ideal heat exchange rate and power utilization is utilized. More prominent heat exchange coefficient increases the heat exchange rate. Heat exchange coefficient increased by increasing flow rate at shell and tube side, coil diameter and pitch and also by applying counter-stream design. Fouling ought to be low in heat exchanger for good execution. Fouling principally relies on upon liquid structure, tube wall temp and material of pipe. For heat exchanger as length decreases ratio of heat exchange to pressure loss increase. In this way, more turbulence, lower pressure drop, higher heat exchange coefficient and additionally less fouling are a portion of the components required for getting better execution of shell and tube heat exchanger (Yingshuang Wang *et al.*, 2011).

The customary segmental baffle (SB-STHX) heat exchanger with have many detriments, for example, drop of pressure is high, low heat exchange efficiency, shell-side stream caused hurtful vibration to tube bundle. At the point when the customary segmental baffle are utilized as a part of STHX, for counter balancing the higher pressure drop higher pumping power is required under a similar heat stack. Consequently, another sort of STHX utilizing diverse sorts of baffle may accomplish higher heat exchange proficiency and lower pressure drop. Two reliant elements that impacting on capital and working expenses of the heat trade frameworks are pressure drop and heat exchange. Keeping in mind the end goal to enhance the execution, higher heat exchange productivity and moderately bring down pressure drop heat exchangers with various sorts of baffle are produced, for example, rod baffle and helical baffle

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exchangers. In this manner, the primary targets of this review are to explore the advancement in STHX with new kind of baffles to defeat the lacks specified previously.

2. Helical vs segmental baffles

Baffle give a superior execution when helical baffles, contrasted with segmental baffle, (Usman Salahuddin *et al*., 2015). He has given a survey about the helical baffles related important work on helical baffle to increase the productivity or efficiency of shell and tube heat exchangers. He talked abouta portion of the central point influencing the execution of shell and tube heat exchanger. He also has done comparative work between segmental HX and helical HX and he presented result as the helical baffles gives out of remaining.

Anas El Maakoul *et al*.has introduced three-dimensional computational liquid elements (CFD) reproductions, utilizing the commercial software ANSYS FLUENT, have been performed to study and think about the shell-side stream circulation,the pressure dropand heat exchange coefficient between the as of late created trefoil-hole, helical baffle and the customary segmental baffle, at low shell side stream rates (Anas El Maakoul *et al*., 2016). The outcomes demonstrate that the utilization of helical baffles brings about higher thermo-hydraulic driven execution while trefoil-hole baffle has a higher heat exchange execution with huge pressure drop contrasted with segmental baffle. Helical baffles indicates 26 % low pressure drop contrasted with segmental baffle. Furthermore, trefoil-hole baffle create the most elevated pressure drop of 135% as contrasted and segmental baffle.

Jian-Feng Yang *et al*. has studied two shell-pass shell-and-tube heat exchanger which is a joined serial with continuous helical baffles. The outcomes demonstrate that the CSTSP-STHX gets pressure drop and more prominent shell-side heat exchange coefficient, moreover it additionally has better heat exchange coefficient under a similar pressure drop than those of the SG-STHX (Jian-Feng Yang *et al*., 2016). Spiral stream, which eliminates leakage dead zone and causes an abatement in fouling is helical baffle also. Although high capital venture is require for helical baffle, low working and support costs made helical baffle use for long haul use (Usman Salahuddin *et al*., 2015).

Helical baffle offer the accompanying points of interest (Cong Dong *et al*. 2015):

(i) Enhanced shell side heat exchange rates/pressure drop proportion;
(ii) Decreased bypass effects;
(iii) lessened shell-side fouling;
(iv)Anticipation of stream incited vibration;
(v) Diminished maintenance.

3. Comparison of different designed baffles.

3.1Plain helical baffles vs ladder-type fold baffle

Jian Wen *et al*. has performed CFD simulation to concentrate the shell side liquid stream and heat exchange execution (Jian Wena *et al*., 2015). The numerical outcomes demonstrated that close to the shell center and shell wall in the original the axial speed is considerably higher. Close to the shell wall temperature is substantially higher and decreases steadily towards the center of shell while for the enhanced heat exchanger, the speed is circulated all the more consistently. Because of the design changethere is no axially short circuit flow. What's more, the temperature is disseminated all the more consistently. The test comes about demonstrated that the heat exchange coefficient at shell-side and general heat exchange coefficient are enhanced by 22.3–32.6% and 18.1–22.5%, separately. Pressure drop is around 0.911–9.084 kPa isgets added in shell side, pumping power punishment is around 2–80 Wwith compared. The heat execution consider TEF upgrades by 18.6–23.2%, which exhibits that the ladder type fold baffle can adequately enhance as compare to helical baffles the heat exchange execution of heat exchangers.

3.2Single layer helical baffles vs two layer helical baffles

In the shell side of STHXs the liquid stream is an entire helix in nature with helical baffle. Keeping in mind the end goal to make full use of the upside of helical baffles and to further enhance shell side heat exchange and resistance execution, a consolidatedtwo-layer continuous helical baffle with shell-and-tube heat exchanger (Jian-Feng Yang *et al*., 2015) is proposed and a photography for utilized as a part of oil refining is introduced in Fig. 1.

Fig.1 Photography of CSSP-STHX used in oil refining (Jian-Feng Yang *et al*., 2015)

By upgrading turbulence it will enhances the heat exchange and on shell side of heat exchangers there is nearby blending. Also, this HX with two layered helical baffle reduce the pressure loss and moderate fouling and prolong the service life of the STHXs with increase in compactness. In two layered helical baffle complex flow is introduced at shell side. Jian-Feng Yang *et al* has done numerical reproduction on two layer helical baffle. Numerical reproductions are completed to think about thermo- hydraulic driven exhibitions of the three heat exchangers which are shell-and-tube heat exchanger with segmental, helical and two layer helical baffle. The outcomes demonstrate that the two layer helical baffle has a higher heat exchange execution while keeping up a lower pressure loss. The two layer helical baffle may be a perfect decision to supplant the segmental baffle and helical baffle in modern applications.

3.3 Trefoil-hole baffles vs helical baffle

Trefoil-hole baffles are new sort heat exchange gadgets and no publications contrasting their execution with customary baffles could be found. Trefoil-hole baffles are broadly utilized as a part of atomic power framework because of their uncommon favorable circumstances (Anas El Maakoul *et al*., 2016). The gap between the orifice edges and tube outside diameter, fluid at shell side flow through this gap. They have great thermos-hydraulic exhibitions while being less at risk to foul, eliminates stagnant distribution zones and maintain a strategic distance from stream incited vibration contrasted with the ordinary STHXs with segmental baffles. Trefoil-hole and segmental baffle create dead zones with noteworthy liquid distribution zones. Helical baffles create the most minimal maximal speeds, a superior stream dispersion, without dead zones and liquid distribution area. hs for the STHX with trefoil-hole baffle is higher overall by around 11% and 9% than hs for STHX with segmental and helical baffle individually. The higher most extreme speeds created with trefoil-hole baffles seriously wash the downstream tube wall, in this manner, result in an eminent heat upgrade on the shell side. On the off chance that another STHX is to be intended to supplant a current one, if the two heat exchangers have equal with pressure drop, the new STHX must have a bigger heat exchange limit, and if the two heat exchanger have break even with heat exchange limit, the new STHX must have a lower pressure drop, in this manner, sparing much pumping power.

3.4 Plate baffles vs rod baffle

Jie Yang *et al* have performed modelling and computational estimations for baffle and furthermore the demonstrating methodology is confirmed with exploratory approach. The values for drop of pressure for the novel one is about 139–147% of the rod baffle heat exchanger. Generally, the novel heat exchanger outlines obviously higher than execution (115–122%) than the rod baffle. rod baffle pressure drop is not as much as that of plate baffle comparatively. Quantitatively, for rod baffle HX the pressure drop is around 28.3– 33.2%. Regardless of whether for rod baffle heat exchanger or the novel shell-and-tube heat exchanger, depend on the effect of flow mechanism heat exchange performance is upgraded regardless of type of HX , for example, vortex and swirl streams, or optional courses created by the arranged rod or novel type baffle. However, the up-wind area of plate baffles is bigger than the rod baffle so that the grooves are littler. When the liquid speed of plate baffle is greater than that of rod baffle at that point water flows through grooves, prompting to a superior heat exchange execution and pressure drop higher. Likewise, it is realized that rod baffle compared with plate baffles creates less swirls and vortexes when hydraulic diameter is at the same order of magnitude. Along these lines, the plate baffle STHX has a superior heat exchange execution and a bigger pressure drop compared with rod one.

3.5 flower vs helical baffle

There are two types of flower baffles can be said as ‘A’ type and ‘B’ type. Flower baffle’ B’ gives the best result compared with ‘A’ type (AmbekarAniketShrikant *et al*., 2016).Both flower baffle having the same pressure loss but ‘B’ type is more effective in heat transfer compared with ‘A’ type. Yingshuang *et al* (2011) did exploratory examinations on flower type of baffle what's more, the original segmental baffle models if we compared with flower baffle it shows that the flower baffle gives the best result compared with segmental under same working condition also most efficient than segmental one.Pressure drop is less compared with seg. Baffle because of less turning angle of baffle. Helical baffle gives best compared with flower baffle so flower baffle can be say that having performance range in-between segmental and helical baffle.

4. Optimum parameter for helical baffle

It can be said from the correlation that helical baffle gives better outcomes among with everything taken into account forthcoming. For getting ideal outcome taking after parameter ought to be investigated before utilizing.

4.1 Continuous vs. discontinuous baffles

Jian *et al*. made an examination amongst continuous helical baffle anddiscontinuous helical baffle. It was found that the comprehensive performance of the discontinuous helical baffle apparently bigger compared with continuous helical baffles while the dead area in continuous helical baffle is wiped out and the heat exchange area is utilized all the more viably (Simin Wang *et al*., 2014). Discontinuous helical baffle assembling is simple when contrasted with continuous helical baffle. Along these lines, discontinuous helical baffle are more productive and achievable than continuous helical baffle.

4.2 Inclination angle

Bin Gao *et al* has done the test examination on five helix angle 8^0,12^0,20^0,30^0 and 40^0.outcome shows that both pressure and heat exchange of small helix is more than the large helix angle with given volume flow rate (shell side). We can explain cause as takes after. At start, with using small helix prompt to small pitch of baffle and a littler stream range at the centerline (shell). In any case, for same condition i.e shell-side Re number, the pressure drop with bigger helix is lower and the heat exchange execution is better. That is, on the grounds that the bigger shell-side speed and less spillage spill out of the triangle zones created by little helix angle. With 40^0 helix angle displays the best complete execution among the all other heat exchanger.

4.3 Low baffle spacing

Pressure slope diminishes with expanding baffle space. At a similar mass stream rate with expanding the confound space the heat exchange coefficientdecreases, for a similar pressure drop builds heat exchange coefficient with expanding the baffle spacing. Baffle spacing likewise relies on upon the prerequisite of the procedure. For greater heat exchange combined with lower heat exchange area, lower baffle spacing is ideal. In the event that pressure loss is an imperative component, for reducing pressure drop and power consumption, longer dividing is required for baffle(F. NematiTaher *et al*., 2012, H. Li, V. Kottke *et al*., 1998). Expanding baffle dividing builds stream speed, which prompts to the upgrade of heat exchange because of a decrease in leakage through baffle shell clearance (H. Li, V. Kottke *et al*., 1998). There is no exact standard to decide the required space between baffle, despite the fact that baffle dividing is an imperative component which influences the capital and working expenses of the heat exchanger. PC projects are for the most part used to decide the ideal baffle separating for a specific heat exchanger sort.

4.4 Increasing number and width of sealing strips

Jian-Feng Yang *et al* did a few tests to demonstrate the execution of helical baffle with the impacts of sealing strips on it. He completed numerical recreations on the stream and heat transfer in helical baffled to study the impact for sealing strips with different combination of number and width. Sealing stripsincreases compelling mass stream rate for liquid through the tube bundle. The outcomes demonstrated keeping the mass stream rate and sealing strip width steady with that by increasing the quantity of sealing strips, heat exchange increments while resistance to stream likewise increments. In addition, the better the heat exchange execution with the bigger the width of the sealing strips will be while the general execution reduces with more number and width of sealing strips. Simin *et al*. clarified that by using sealing strips shell side gap gets block because of that area reduce with reduction in circulation, also increase the flowrate and henceforth the execution (shell side) is upgraded. As increase in flowrate, pressure drop likewise increments. Power utilization likewise increments because of the establishment of sealing strips, yet it is compensated by the addition of heat rate per area (S. Wang *et al*., 2009).

Conclusions

1) It can be finished up from the review study that helical baffle gives preferable outcomes over the segmental ones because of better heat exchange execution, less fouling and less liquid prompted vibrations.
2) The pressure drop for the STHX with helical baffle is around 26% lower than the pressure drop for the STHX with segmental baffle.
3) Heat exchange coefficient of the CH-STHX is around 13.1% higher than SG-STHX.
4) Double layer helical baffle give less pressure drop compared with different baffle. The general pressure drop Δpm of the Double layer helical baffle is around 13% lower than that of the single layer helical baffles.
5) Under a similar mass stream rate M, the far reaching execution h/Δpm of the CSSP-STHX is around 39.7% and 6.1% higher than those of the SG-STHX and CH-STHX, individually.
6) Heat exchange coefficient for the STHX with trefoil-hole baffle is higher overall by around 11% and 9% than STHX with segmental and helical baffle individually.
7) From the review study it can be said that helical baffle gives best out of available baffles with minimum pressure drop for same heat transfer. By cost consideration point of view it could be better.

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